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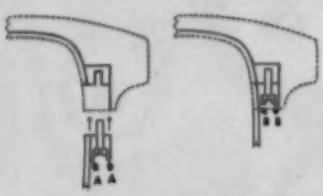

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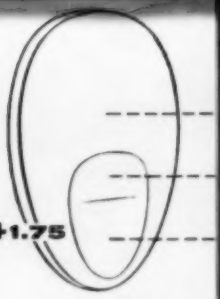

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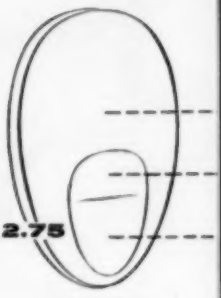

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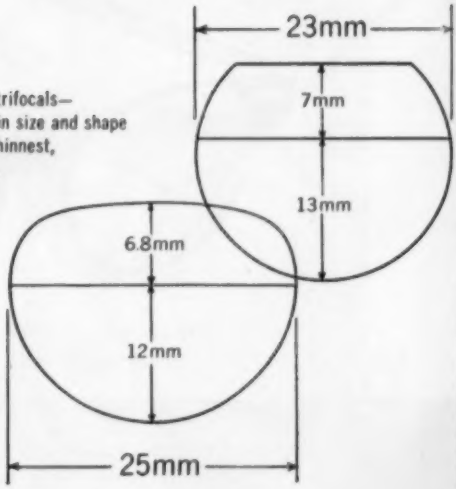

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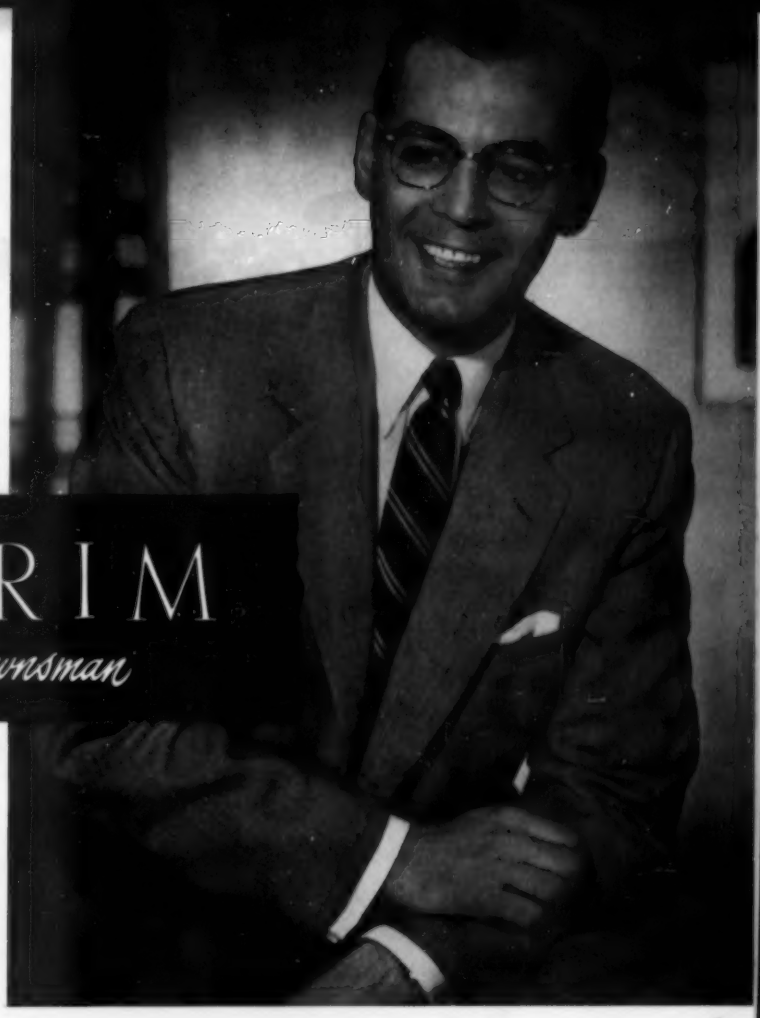

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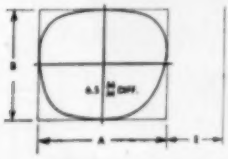

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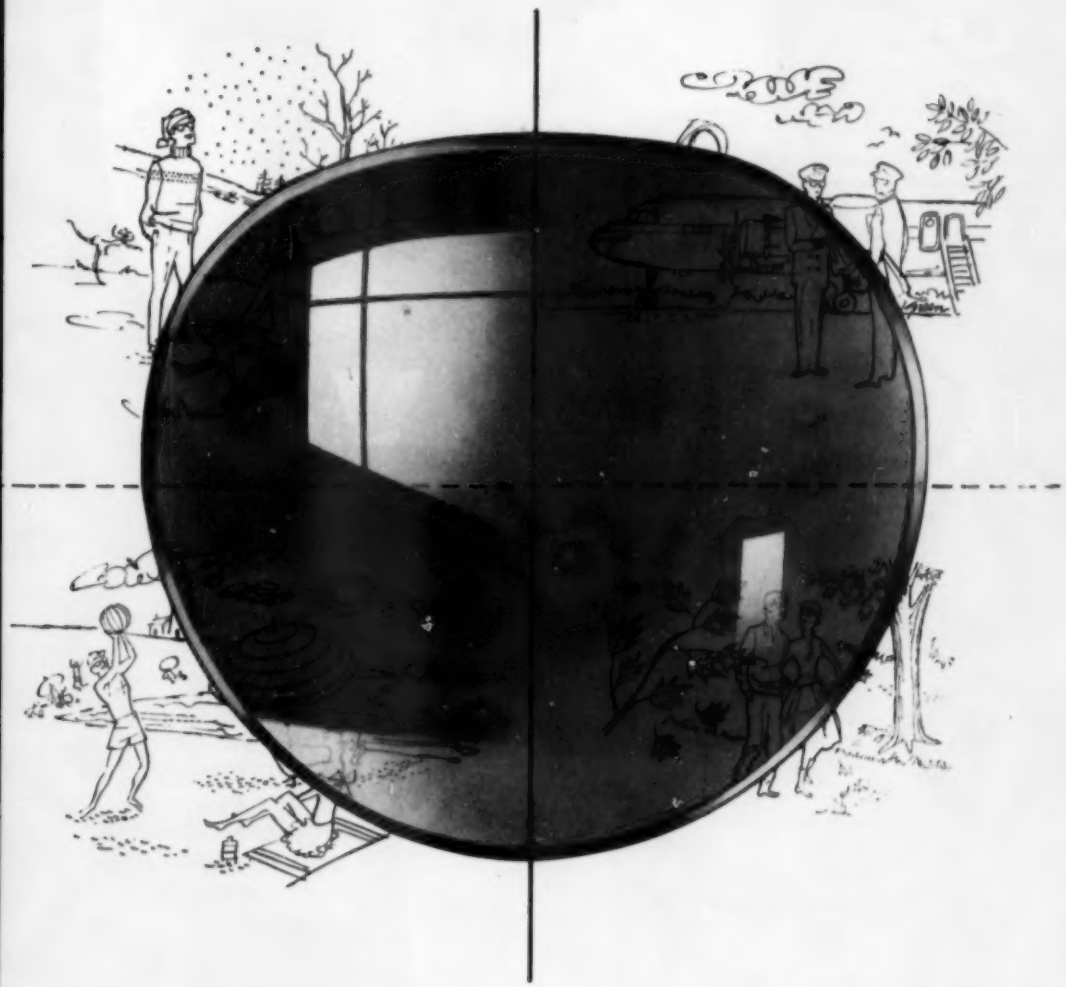

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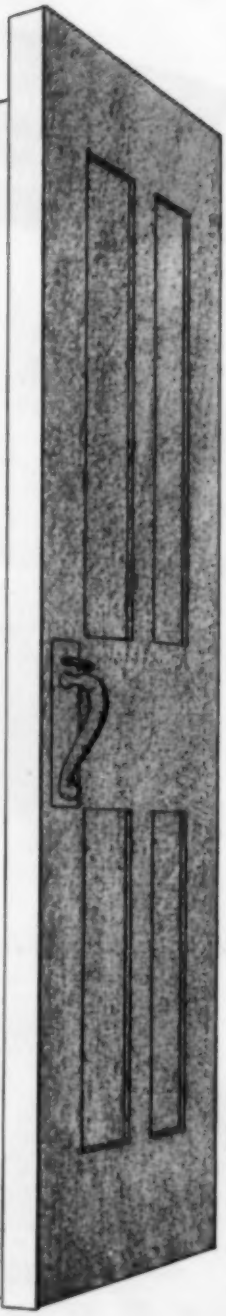

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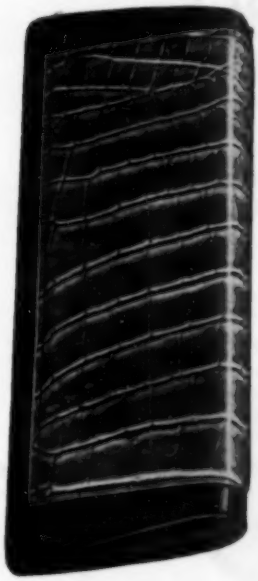

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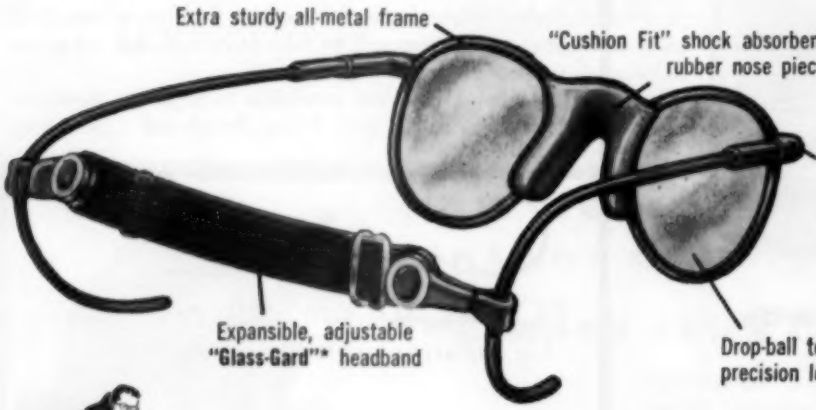
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Vol. 31 November, 1954 No. 11

INDUCEMENT OF CYCLOFUSIONAL MOVEMENTS*

V. J. Ellerbrock†
School of Optometry, The Ohio State University
Columbus, Ohio

INDUCEMENT OF CYCLOFUSIONAL MOVEMENTS

It has been amply demonstrated that cyclofusional movements occur under varying conditions in the interest of maintaining single binocular vision. An historical survey of this problem has been provided in a relatively recent publication and consequently is not warranted in this paper.[1]

In the study of cyclofusional movements, interest usually has centered about the amplitude of these movements. Although such data certainly are desirable, they provide little or no insight into the nature of the movements during inducement. Only by a careful study of the inducement can a satisfactory understanding be obtained regarding the binocular use of the two eyes.

A report of an extensive study of cyclofusional movements to relatively small angular rotations of the images for the eyes was provided by Ogle and Ellerbrock in 1946.[1-4] In these investigations stereoscopic methods of spatial localization were used to measure the response of the eyes and it was found that cyclofusional movements occur much more freely than previously was realized. When the contours made up complex spatial arrangements that provided stimuli for cyclofusional movements of different amounts and different directions, the movements that took place tended to compromise the antagonistic compulsions resulting from these contours. However, it was shown that contours whose images in the two eyes are vertical or nearly vertical provide much stronger stimuli for cyclofusional movements than do those from contours whose images are horizontal.

These investigations also showed that with only vertical contours as stimuli, the response of the eyes to angular rotations not exceeding $\pm 0.8^\circ$ was relatively complete. These results are illustrated in Figure

*Read before the annual meeting of the American Academy of Optometry, Chicago, Illinois, December 5, 1953. For publication in the November, 1954, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.

†Optometrist, Ph.D. Associate Professor of Optometry. Fellow, American Academy of Optometry.

1. They were obtained when the test element consisted of a single stationary vertical cord and the declination or rotation of the images

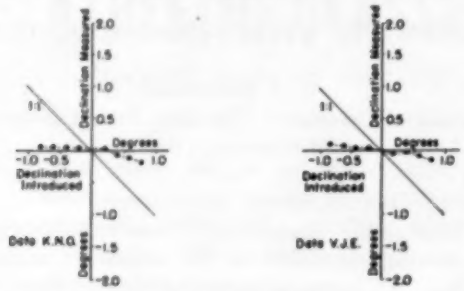


FIGURE 1. TYPICAL DATA FROM THE INVESTIGATION BY OGLE AND ELLERBROCK ILLUSTRATING THE RESPONSE OF THE EYES TO CYCLOFUSIONAL STIMULI. THE TEST ELEMENT WAS A SINGLE VERTICAL CORD AND THE DECLINATION WAS INTRODUCED BY MEANS OF PAIRED MERIDIONAL MAGNIFYING LENSES.

was introduced by means of paired meridional magnifying lenses. If the eyes did not respond to the declination of the images, the data would have fallen along the line marked 1:1: the response of the eyes to the declination is indicated by the proximity of the data to the abscissa of the graph. From a study of the figure, it is apparent that the eyes responded almost completely to the declination.

In order to determine the response of the eyes to rotation of the images of greater magnitude than that previously studied, the present investigation was undertaken. In it, an attempt was made to achieve the same accuracy and control as in the experiments described above.

APPARATUS

The apparatus employed in this investigation is schematically illustrated in Figure 2. For description, it is convenient to separate the instrument into two parts: one, the components used to induce cyclofusional movements and two, those employed to measure the response of the eye.

The components used to induce the movements consist of a dove prism, apertures to restrict the field of view, and a device to rotate the test elements. The dove prism was mounted only before the right eye: with the prism it was possible to provide equal and opposite stimuli for the two eyes with a single test element.

It is interesting to note that Helmholtz suggested the use of a dove prism in the study of cyclofusional movements. He also considered the possibility of using two right angle prisms oriented as shown in Figure

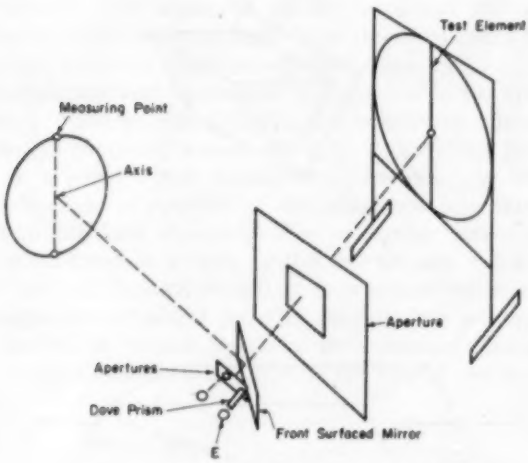


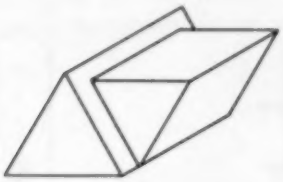
FIGURE 2. SCHEMATIC ILLUSTRATION OF APPARATUS FOR MEASURING THE AMPLITUDE OF CYCLOFUSIONAL MOVEMENTS

3A. In use, the prisms could be rotated together as a unit or one prism could be held stationary while the second prism was rotated.[8]

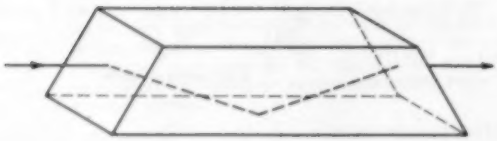
The optical principle of the dove or rotating prism is illustrated in Figure 4. If AB represents the position of a test element, A′B′ illustrates the position of the image of the test element viewed through the prism. With a dove prism, the image of a test element is rotated through an angle 2ω, i.e., twice as much and in the opposite direction to the test element itself. Since the test element in all experiments was a uniform cord, the inversion of the image through the prism did not present a problem.

The device to rotate the test elements consisted of a rigid metal ring 105 centimeters in inside diameter. It was accurately machined and mounted between four ball-bearing rollers. The rollers were located at the points where the ring became tangent to the metal supporting frame. The center of the ring was 130 centimeters from the floor and located 3 meters from the subject's eyes. With a pointer mounted to the ring and a scale mounted to the supporting frame, the position of a test element mounted to the ring easily could be set to 0.1°.

In the experiments to be described the test element consisted of a



A.



B.

FIGURE 3. TWO DESIGNS OF THE DOVE OR ROTATING PRISM

seen against a flat black background located two meters behind it and uniform white nylon cord one mm. in diameter. The element was carefully designed to eliminate all empirical cues to spatial localization.

Illumination for the test elements was provided by two 40-inch fluorescent tubes mounted vertically and 40 centimeters in front of

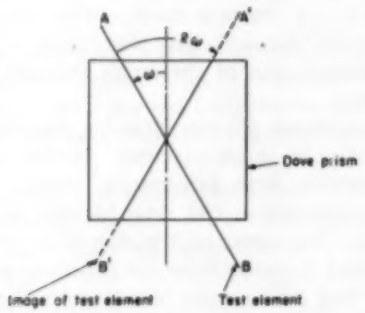


FIGURE 4. ILLUSTRATION OF THE ROTATION OF THE IMAGE A'B' OF A LINE AB WHEN VIEWED THROUGH A DOVE PRISM

the test element. The separation of the tubes was 100 centimeters; suitable baffles prevented stray light from the illuminants from reaching the subject's eyes or illuminating the background.

The apparatus used to measure the position of the eyes consisted of two small point sources of light, a semi-silvered mirror, and the dove prism. The point sources of light (measuring points) were mounted on a wheel which rotated about an axis. As illustrated in Figure 2, the plane of rotation of the wheel was approximately perpendicular to the lines of sight. The measuring points were intermittently illuminated at a cycle of 0.8 sec. on and 1.2 sec. off. By this means the cyclofusional stimuli of these points was minimized.

The semi-silvered mirror provided roughly fifty per cent reflection. With the mirror, the vertical images of the measuring points were seen to be in the same plane and slightly to the side of the test elements. (Figure 5.)

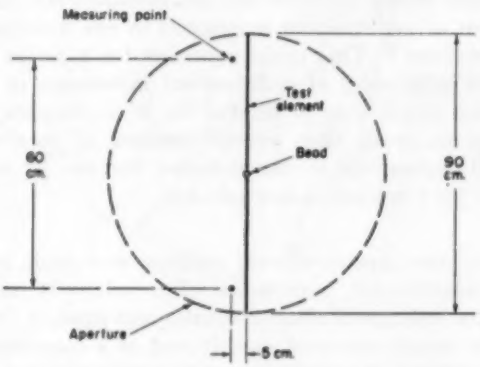


FIGURE 5. ILLUSTRATION OF THE RELATIVE POSITION OF THE TEST ELEMENT AND MEASURING POINTS

The position of the measuring points could be changed by the subject. For this purpose a pulley system consisting of weights, cord, etc., was provided. Since the wheel and all the pulleys operated very easily, the measuring points could be set to an accuracy of 0.1°. A pointer attached to the wheel and a scale attached to the mounting for the wheel provided measurement of the position of the measuring points.

In order to restrict the field of view of the subject, apertures were mounted in front of the eyes as illustrated in Figure 2. The size of this field was 17.5 degrees in diameter. The subject's head was held firmly in position by means of a chin cup and head supports.

PROCEDURE

It is generally agreed that fusional movements develop slowly and increase until a constant level is attained and this level is then maintained so long as fusional stimuli are active.[7] On this account, the procedure was followed in each experiment of increasing the separation of the images of the test elements, one degree per two minute intervals.

In every experiment, the test element was first set at the zero position. The subject fixated a bead at the center of the test element for approximately one and one-half minutes and then set the measuring points so that the one was directly above the other, i.e., subjectively vertical. A minimum of three settings of the measuring points was made for each position of the test element. At the end of the two-minute period, the angular separation of the images of the test elements was increased one degree, and the same cycle repeated.

It has been shown by Hofmann and Bielschowsky that following the inducement of cyclofusional movements in one direction, a residual tonicity is produced.[5] This tonicity persists for a period of time: it will affect the inducement of cyclofusional movements in the opposite direction unless ample time is allowed for it to disappear.

In order to avoid such residual tonicity in these experiments, only fusional movements in one direction for one set of conditions were induced for a subject in any one day.

RESULTS

In all of the experiments the attempt was made to induce the maximum cyclofusional movements. For relatively small angular separations, the response of the eyes usually was equal to the separation. This response usually occurred quickly and as a consequence the subjective impression of the observer was that the cord was vertical. As the angular separation of the images of the test element was increased, the response of the eyes became slower. As a result, the cord first would appear inclined with the top end either tilted away from or toward the observer: after a minute or so of observation the cord again would become vertical. With further increases in the angular separation, the response of the eyes gradually lagged even after the stimulus pattern had been observed for a two minute interval. Thus, the line always would appear tilted from the subjective vertical position.

In order to appreciate the experiences of a subject during an experiment, consider Figure 6. At the top of this figure the stereoscopic vertical and horizontal meridians of the eyes are indicated by the broken lines: the solid lines represent the images of a test element with an

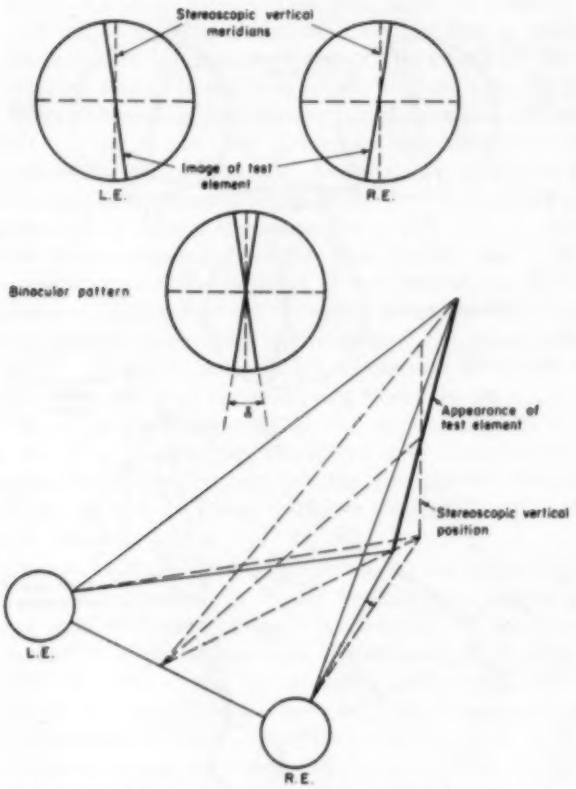


FIGURE 6. (TOP) THE IMAGES OF THE TEST ELEMENT ARE ROTATED FROM THE STEREOSCOPIC VERTICAL MERIDIANS. (BOTTOM) THE BINOCULAR SPATIAL LOCALIZATION OF THE TEST ELEMENT

angular separation. For convenience, let the angular separation be called δ and the response of the eyes τ. Since δ is a finite quantity and τ is zero, the spatial localization of the line in space will appear tilted away from the subjective vertical position. As the eyes respond to the angular separation and $\tau \rightarrow \delta$, the line will become less tilted; when $\tau = \delta$ the line again will appear vertical.

The appearance of the test element when the response of the eyes roughly is one-half of the angular separation of the images of the test element is shown in Figure 7. For this figure, the images of the test

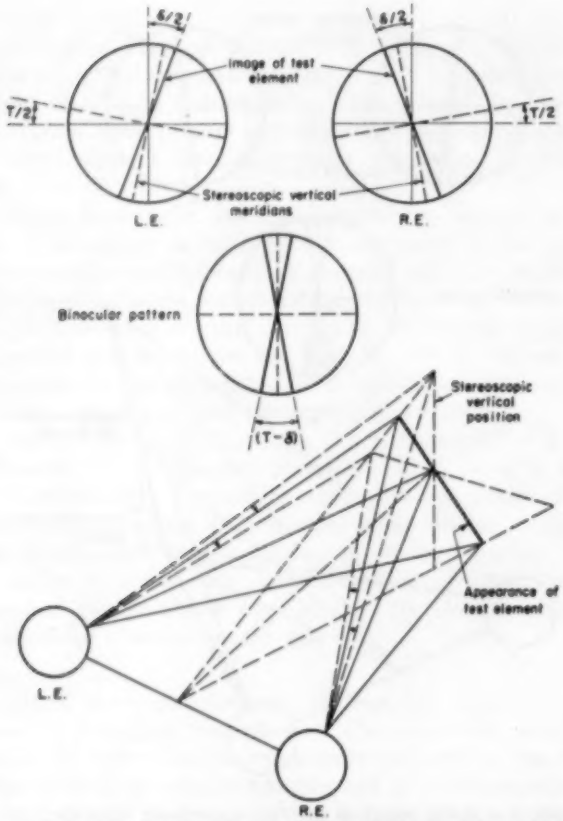


FIGURE 7. (TOP) RELATIVE POSITIONS OF THE IMAGES OF A TEST ELEMENT AND THE STEREOSCOPIC VERTICAL MERIDIANS. (BOTTOM) THE BINOCULAR SPATIAL LOCALIZATION OF THE TEST ELEMENT.

elements were rotated in the opposite direction to that illustrated in Figure 6.

In measuring the response of the eyes in the following experiments, there were two different methods that could be utilized. In the one, the measuring points were set so that they appeared to be vertical. The angular position of the points from the vertical position then provided a direct measurement of the response. In the second method, the measuring points were set so that they appeared to lie in the plane of the cord: the position of the measuring points then provided a direct

measure of the amount that the eyes had failed to respond to the stimulus. Of the two methods the one described first is superior because of the ease with which the setting of the points in the vertical position could be made. If one tries to set the points in the plane of the cord when the cord is considerably tilted in space, the setting is very difficult; in fact, under some conditions this difficulty is enhanced by a diplopia of the ends of the line. Usually, the ends would appear to lie in the plane of the fused portion of the cord but not always.

The method of setting the measuring points vertical, introduced a variable in the experimental procedure that initially had to be evaluated. In a previous part of this paper, it was pointed out that stimuli for cyclofusional movements of different amounts and conditions produced movements that tended to compromise the antagonistic compulsions to the different stimuli. With relation to these experiments, it is seen that the setting of the measuring points in the vertical plane produced an antagonistic stimulus to the angular separation of the images of the cord. To be sure, the intermittent illumination of the points tended to weaken or diminish the strength of the points as stimuli for the movements but nevertheless their effect still had to be considered in the experiments.

As illustration of the effect of the setting of the measuring points, consider the results presented in Figure 8. For these results a single white nylon cord was used as the test element. In the graph, the stimulus is plotted as the abscissa and the response of the eyes as the ordinate. For the data in A, the measuring points were left in the vertical position following the measurement of the response of the eyes; for B, the points were adjusted so that they appeared to be in the plane of the cord after measuring the response of the eyes. Thus, in the former case, the stimuli from the measuring points and cord were antagonistic; in the latter, they were complimentary. In both experiments, the subject continually fixated a bead at the center of the cord and only paid attention to the measuring points when a request was made to set them in a particular position, i.e., vertical or in the plane of the cord. The fact that the amplitude in the one case is almost double that found in the other case clearly indicates the important role of the measuring points in experiments of this nature.

The data in Figure 8 also illustrate another important finding. From a study of the figures, it is seen that the curve of the line connecting the various points is quite irregular. This indicates that the responses of the eyes for some stimuli were almost equal to stimuli; for others, there was quite a discrepancy and the responses lagged

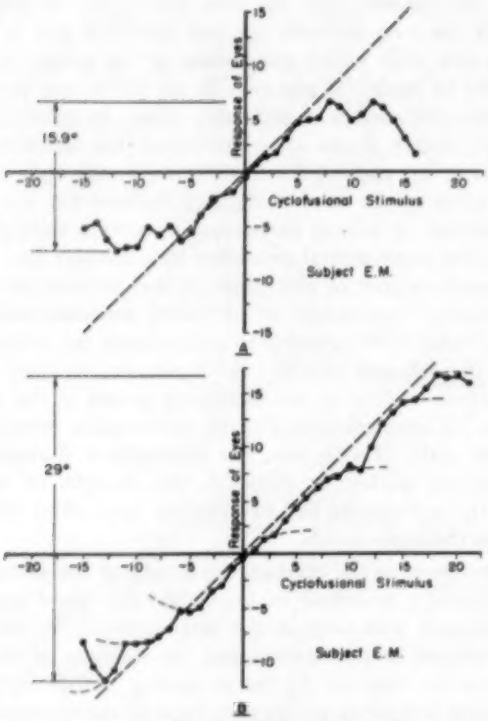


FIGURE 8. DATA ILLUSTRATING THE RESPONSE OF THE EYES TO CYCLOFUSIONAL STIMULI. IN A, THE MEASURING POINTS WERE LEFT IN THE VERTICAL POSITION FOLLOWING THE MEASUREMENT OF THE RESPONSE OF THE EYES; FOR B, THE POINTS WERE ADJUSTED SO THAT THEY APPEARED TO BE IN THE PLANE OF THE CORD IMMEDIATELY AFTER MEASURING THE RESPONSE OF THE EYES.

appreciably behind the stimuli. In fact, from a study of the data, it is seen that the responses of the eyes usually followed the stimuli over a limited range, and then gradually and increasingly fell behind. When the lag became quite large, cyclofusional movements again were induced and the lag either became quite small or disappeared. The cycle then was repeated as the stimuli were increased in size.

The repeatability of the measurements in these experiments is shown in Figure 9. These data also illustrate the same asynchronous response of the eyes as found for the subject whose results are shown in Figure 8. However, it is interesting to note that for subject V. J. E. the midpoint of the range of cyclofusional movements was considerably dis-

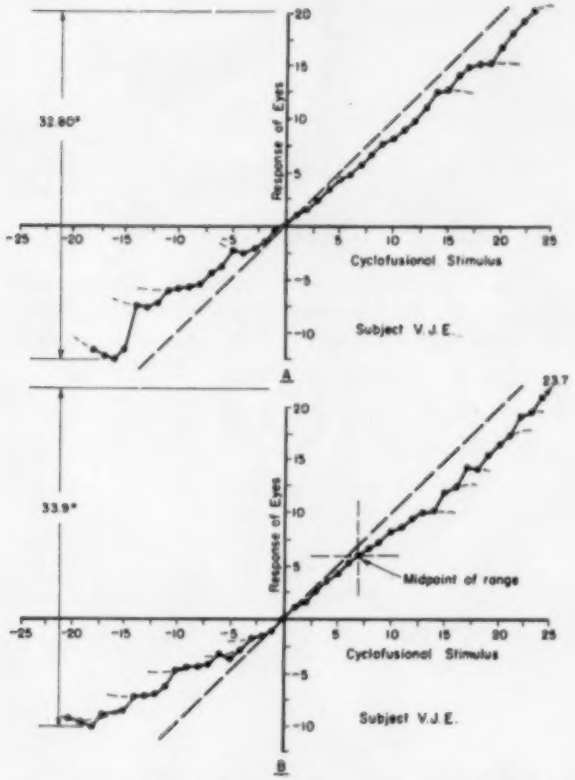


FIGURE 9. RESULTS FROM TWO IDENTICAL EXPEREMENTS WITH A SUBJECT TO SHOW THE REPEATABILITY OF THE DATA. THE MIDPOINT OF THE RANGE OF CYCLOFUSIONAL MOVEMENTS IS DISPLACED FROM THE ZERO POSITION OF THE STIMULI INDUCING THE MOVEMENTS.

placed from the zero position of the stimuli inducing the movements.

CORRELATION OF OBJECTIVE DATA AND SUBJECTIVE REPORTS

The failure of the response of the eyes to equal the stimulus in these experiments, invariably produced an alteration in the spatial localization of the cord. If the lag was only small: the cord would be slightly tilted: if it was quite large, the cord would be considerably tilted in space and one or both ends of the cord might be seen double. With further increases in the lag, the images of the cords would finally break, and the subject would see two images forming an X (Figure 10).

The appearance of the cord as reported by one subject is presented

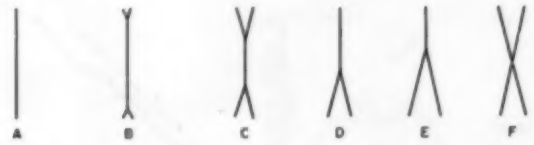


FIGURE 10. THE APPEARANCE OF THE CORD AS SEEN WITH SUCCESSIVE INCREASES IN THE LAG OF THE RESPONSE OF THE EYES AND THE STIMULUS. IN A, THE IMAGES OF THE CORD ARE COMPLETELY FUSED; IN F, THE IMAGES ARE UNFUSED, AND APPEAR AS AN X.

in Table 1.* In this table, the estimated as well as the calculated tilt of the cord are provided. The calculated data were computed for the measured lag between the response of the eyes and the stimuli by use

TABLE 1.
DATA OF THE ESTIMATED AND CALCULATED POSITION OF THE TEST ELEMENT FOR SUBJECT V. J. E.

Stimulus	Tilt of Cord (degrees) Estimated	Calculated	Percentage Fusion of Images	Description
+20	70	68.7	25	Entire length of cord occasionally seen in diplopia.
+15	50	61.2	35	Ends of lines appear double.
+10	45	54.8	85	Slight doubling at top end of cord.
+ 5	15-20	29.0	100	No diplopia.
0	0	0	100	No diplopia.
— 5	45	67.2	100	Occasional diplopia for ends of cord.
—10	60	73.6	40	Diplopia for more than half the length of the cord.
—50	70-80	69.8	50	Whole length of cord occasionally appears double.

of the relation: $\tan i = b/2a \tan (\delta - r)$ where i is the inclination of the cord in degrees, b is the distance of fixation, a is ½ the interpupillary distance, δ is the cyclofusional stimulus and r is the response of the eyes.

It is interesting to note the agreement of the subjective and calculated tilt of the line. This agreement certainly shows that the testing situation provided in the experiments permitted the spatial effects from stereopsis easily to become manifest. The estimated percentage fusion of the images and report of diplopia also are provided in Table 1.

DISCUSSION

In the past, various methods have been used to measure the

*Original data given in Figure 9A.

inducement of cyclofusional movements. Generally, these consisted of haploscopic arrangements in which one or both targets were rotated to provide the stimulus for inducement. The measurement of the response was provided by linear alignment of a line such that the parts seen by the two eyes appeared continuous and straight or the setting of two lines parallel when only one line was seen by each eye. It is believed that the method described in this paper is a significant improvement in that a much more sensitive index of response of the eyes was employed.* Another feature of this method is that the stimulus pattern for the two eyes is identical.

An interesting observation of the subjects was that the ends of the lines seen in diplopia usually had the same spatial localization as if they were fused. Only when the separation of the images became quite appreciable was this effect lacking. These findings essentially are in agreement with those recently reported by Ogle in a measure of the limits of stereoscopic vision.[9] Ogle found that there are two ranges of depth with images seen in diplopia. In one, there is a strong patent experience of stereoscopic depth; in the other, there is only a qualitative sense that both double images are seen farther or nearer than the fixation point, depending upon the direction of the disparity. For patent stereopsis, the range of disparities at a peripheral angle of 6 degrees was 70 minutes of arc; the range for the qualitative sense of depth at the same peripheral angle was 2 degrees. With these data and the results presented above, one can predict the experiences of the subjects in various types of experiments.

Perhaps the most important finding in these experiments is the nature of the response of the eyes. In a search of the literature, this finding has not been found to be heretofore reported.

Why do the eyes respond asynchronously to a stimulus that continuously is altered in discreet and equal amounts? For a detailed analysis, the horizontal size of Panums areas in the stereoscopic vertical meridian for various peripheral angles would have to be known. Also, the potential for inducing cyclofusional movements in discreet areas in the vertical meridian would have to be determined. Unfortunately, at the present time there is not sufficient data to warrant such an analysis of the problem.

The amplitudes of cyclofusional movements found in these experiments are quite large. In fact, in comparison to other reported data in the literature, they are the largest encountered to date. The range of

*The average deviation of the sitting varied from 0.1 to 0.4°. The larger values always were encountered in the response of the eyes to large cyclofusional stimuli.

findings for previous investigations did not exceed 20 degrees: some were as low as 12 degrees.[7] Without doubt, the difference can be attributed to methodology.

Although large amplitudes were found in the experiments described above, the possibility exists that even larger amplitudes will be obtained when the stimulus pattern is more complex. For example, the simple addition of more cords should increase the size of the amplitudes. These experiments as well as many others to further increase the available knowledge about these movements await future investigation and research.

Appreciation is expressed to Dr. Earl Miller for participation in the experiments described in this paper.

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BOOK NOTICE

HUGH ROY CULLEN, by Edward Kilman and Theon Wright. Published by Prentice-Hall, Inc., 70 Fifth Ave., New York City. Illustrated. 376 pages. Cloth. $4. 1954.

Hugh Roy Cullen is a conservative of remarkable stature and he is the man whose substantial gifts made the University of Houston possible. Many optometrists will be interested in reading of this remarkable Texan who set up the campus on which one of our newer Optometry Colleges is located. Mr. Cullen is a man of great wealth (oil) and he will long be remembered for his philanthropy: for his determined and effective opposition to the New-Deal in Washington, and for his early helpful support of President Eisenhower.

CAREL C. KOCH

BRIGHTNESS DIFFERENCE IN SEEING*

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An important objective of illuminating engineering is to develop footcandle recommendations on a sound basis. However, such a basis must be a practical one. Many laboratory studies have been conducted to help solve this problem. These studies generally have involved the evaluation of some aspect of visual performance such as speed, accuracy, size discrimination, or others. Numerous attempts have been made to apply these laboratory measurements to lighting practice. However, this has been almost impossible because of the great difficulty involved in relating threshold observations to suprathreshold seeing conditions.

It should be obvious that a high degree of visual performance—speed and accuracy—and optimum ease of seeing cannot be achieved without a corresponding high visibility level. Increasing the illumination on a visual task (up to a limiting value generally well above present day lighting practice) increases its visibility. How do increases in illumination provide better seeing? The usual simple explanation is that the higher footcandle levels produce higher task brightnesses which enable one to see better. But, then why are these higher task brightnesses more effective? It is well established that at higher adaptation levels the eye becomes more sensitive and can discriminate smaller percentage brightness differences. Therefore, it seems logical to explore the possibility of applying the brightness difference concept to suprathreshold seeing.

In the usual sense, the brightness of a task is considered to be the brightness of the immediate background against which the details of a task are viewed. However, changes in background brightness produced by changes in illumination are accompanied by changes in object brightness. It is the brightness difference between the object and its background which becomes a significant index in evaluating the effectiveness of illumination.

Any specific visual task can be defined and described by its size and by the contrast between the details and their immediate background.

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†Illuminating Engineer. Fellow, American Academy of Optometry.
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Other factors such as color, viewing time, movement, etc., also are important, but for simplicity are omitted from this discussion. In any particular visual situation the factors of size and contrast remain constant regardless of the level of illumination. When the footcandle level is increased, the only corresponding changes in the task are the brightnesses of the object and its immediate background. If, in analyzing the improved visibility, only the background brightness is included, no consideration is given to the effect of the illumination upon the object. Thus, it is difficult to develop a general concept of suprathreshold seeing which can be applied to any visual task. It seems to be desirable to be able to relate suprathreshold conditions to a basic and fundamental measurement which does not involve any physical change in the task being viewed. Furthermore, the variable should be an inclusive one which adequately reflects the complete effects of various footcandle levels upon the task. On this basis, measurements of threshold size, contrast or viewing time appear to be inadequate for describing suprathreshold conditions.

Measurement of brightness differences can be related to any visual task and extended to all suprathreshold conditions. It bears a relation to contrast in that the latter can be considered as relative brightness difference. However, by placing it on a relative basis, the significance of the absolute values of brightness is lost. The contrast C of an object with its background usually is expressed by

$$C = \frac{R_b - R_o}{R_b} \qquad (1)$$

where R_b and R_o are the background and object reflectances, respectively. Contrast also can be expressed in terms of the background brightness B_b and the object brightness B_o:

$$C = \frac{B_b - B_o}{B_b} \qquad (2)$$

Brightness difference, $\triangle B$, is given by

$$\triangle B = B_b - B_o = CB_b \qquad (3)$$

Since the brightness of a surface is the product of its reflectance R and the illumination E, brightness difference may be determined from

$$\triangle B = E(R_b - R_o) \qquad (4)$$

From these expressions it can be seen that brightness difference varies directly with the illumination, while contrast remains constant. These expressions for brightness difference are convenient only if the background is lighter than the object. When the object is lighter than the background, values of brightness difference will be negative. In prac-

tice, only the absolute brightness difference is significant.

It is evident that contrast alone is an inadequate description of a visual task. Identical contrasts can be obtained with different combinations of brightnesses (or reflectances). For example, background and detail reflectances of 80 and 40 per cent provide the same contrast as 8— and 4— per cent reflectances. Both combinations have contrasts of 50 per cent. However, if the two tasks are illuminated by 10 footcandles, the brightness differences are 4.0 and 0.4 footlamberts, respectively. Obviously, the two tasks cannot be of the same visibility nor is it conceivable that they could be performed with the same speed and accuracy with a given level of illumination. This is further evidence of the need for a better method for evaluating the effectiveness of footcandles.

Considerable data are available that can be used to check the relationship between threshold and suprathreshold seeing. Many of them are in terms of contrast and background brightness, which can be converted into brightness difference. Nevertheless, it was decided to obtain new data to establish the general trends and validity of these relationships and of the brightness difference concept. Furthermore, it was particularly desired to determine the applicability of suprathreshold visibility appraisals to this concept.

The first step was to determine the threshold illumination for a series of test objects of equal size, but of various contrasts. The objects selected correspond to the Snellen E. They were reproduced so that at a viewing distance of 20 feet the stroke width subtended a visual angle of 2.25 minutes. The overall heights of the letters were five times the stroke widths and subtended visual angles of 11.25 minutes. Physical data pertaining to these objects are presented in Table I. While it is difficult to reproduce these objects accurately, Figure 1 will aid in visualizing them. High, medium and low contrasts were obtained with various combinations of object and background reflectances. It will be noted that identical contrasts were obtained with objects 2 and 4 by different reflectance combinations. This pair afforded an opportunity to make direct comparison of the brightness difference required for the threshold condition for light and dark backgrounds. Objects lighter than their backgrounds were not included because no significant differences have been found for the range of sizes and contrasts usually encountered in typical seeing situations.[1]

Eleven young adult observers, all with normal vision, determined the threshold illumination. That is, the illumination was adjusted until the E's were just barely recognizable. The average threshold

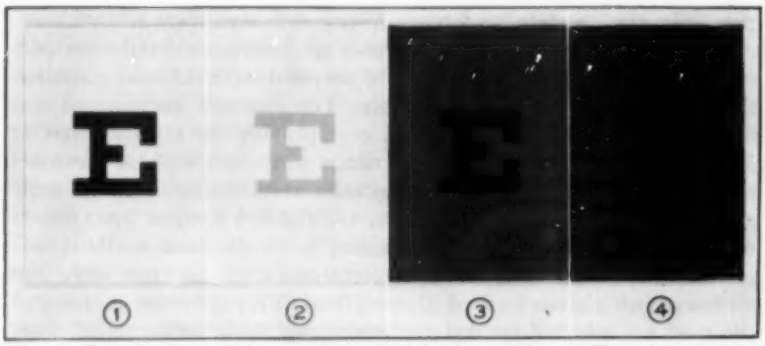

Fig. 1. Reproductions of the test objects used in the experiment. From left to right they represent approximately the contrasts of the four letters, described in Table I.

footcandle levels for the four test objects, presented in Table I, show no relationship to contrast. However, there is an approximately linear relationship between the logarithms of reflectance difference and threshold footcandles. On the other hand, there is a direct relationship between brightness difference and contrast.

It is interesting to compare the results obtained with objects 2 and 4. These objects have identical contrasts but reflectance differences of 13.5 and 0.68 per cent, respectively. The threshold illuminations required for this pair of letters were 0.95 and 18.4 footcandles. The observed brightness differences are equal. Similar results were obtained with a smaller pair of E's, but with considerably higher levels of illumination. These data indicate that two visual tasks of identical contrasts obtained by different combinations of reflectances can be brought to an equal level of discrimination by footcandle levels which provide the same brightness difference.

TABLE I

Physical and threshold data pertaining to the four letter E test objects. Reflectances and contrasts are expressed in per cent and brightnesses in footlamberts.

	TEST OBJECT			
Physical Data	1	2	3	4
Background reflectance, R_b	85.7	89.8	6.49	4.52
Object reflectance, R_o	2.6	76.3	3.38	3.84
Reflectance difference, ΔR	83.1	13.5	3.11	0.68
Contrast, C	97.0	15.0	48.0	15.0
Threshold Data				
Footcandles	0.044	0.95	2.36	18.4
Relative footcandles	1	22	54	420
Background brightness, B_b	0.038	0.85	0.15	0.83
Object brightness, B_o	0.001	0.72	0.077	0.70
Brightness difference, ΔB	0.037	0.13	0.073	0.13
Relative brightness difference	1	3.5	2	3.5

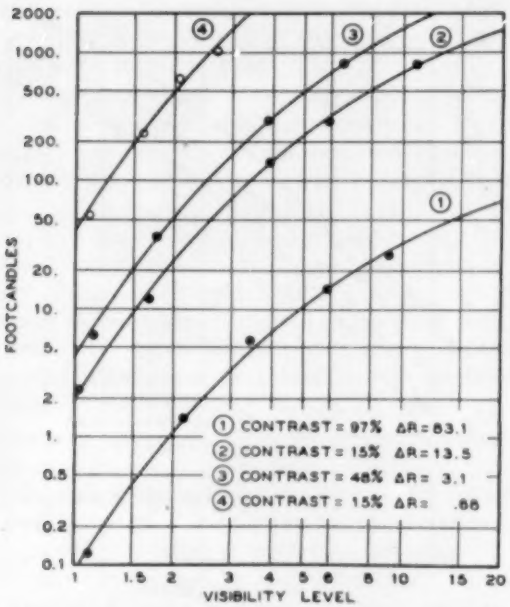

Fig. 2. The relationships between footcandles and suprathreshold visibility level for four letter E test objects having various contrasts and reflectance differences.

In Figure 2 are shown the relationships between visibility levels, as indicated by the Luckiesh-Moss Visibility Meter, and footcandles for each of the E's. As would be expected, the lower contrast objects require considerably higher footcandle levels than the high contrast objects for any given visibility level. For example, the required footcandles for a visibility level of 2 are 1, 24, 52 and 500. These are in approximately the same ratios as the threshold footcandles presented in Table I. Furthermore, since the curves of Figure 1 are essentially parallel, these ratios are practically constant for all visibility levels. In other words, the visibility meter indicates relative suprathreshold footcandles of the same order as threshold observations.

These footcandle values bear no obvious relationship to the physical data of the objects, though they can be arranged in the same order as the reflectance differences. However, an analysis of other data has indicated that such a relationship is continuous only when either the reflectance of the object or of the background is a constant. For example, the relationship between visibility level and reflectance difference of a

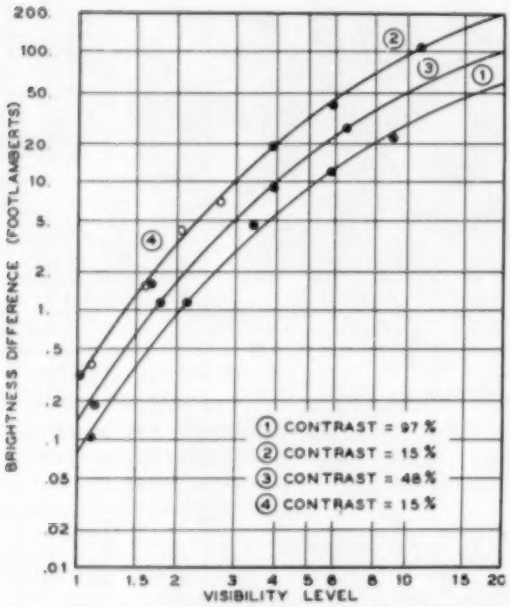

Fig. 3. The data of Fig. 2 replotted in terms of brightness difference and visibility level.

series of objects of the same size, all with white (80 per cent) backgrounds, can be represented by a smooth curve. A different curve will be required for a different background reflectance. This probably is the reason why some experimental data presented in terms of contrast appear rather variable. When the data are so presented, different curves will be obtained for identical values of contrast as indicated by curves 2 and 4 of Figure 2. None of these relationships is unexpected, but they do serve to emphasize the importance of the reflectances of both the object and its background.

When the data of Figure 2 are plotted in terms of brightness difference, the curves of Figure 3 are obtained. Here the curves for test objects 2 and 4 fall together and the three curves are in the same relative order as the contrasts involved. These curves indicate that for a given contrast, however obtained, brightness difference is a constant for a specific visibility level. This also is illustrated in Table I by the threshold values of brightness difference for these two objects. The relative values of brightness difference from threshold data (Table I) are 1, 2 and 3.5 as compared to 1, 1.8 and 3.5 for the visibility data

(Figure 3) at any visibility level. In other words, the L-M visibility meter rates the objects in the same order and to the same relative degree as they are rated on a threshold basis.

Table II has been developed from comprehensive visibility data for a series of parallel bar test objects of various sizes and contrasts.[2] The tabulated values illustrate the effect of size and contrast upon the brightness difference required for visibility levels ranging from 1 to 10. A visibility level of 1 indicates that an object is just barely visible when viewed through the clearest portion of the gradients of the Luckiesh-Moss Visibility Meter.[3] Since there is some absorption by this part of the gradient, the absolute threshold of visibility of a task when it is viewed without the visibility meter will be obtained with a slightly lower footcandle level. From available data it has been determined that the threshold illumination is approximately one-fourth of the illumination required for a visibility level of 1.

To obtain any given visibility level, the required brightness difference must be increased as the contrast is decreased. For example, when the 3-minute test object has a contrast of 95 per cent (black on white), a visibility level of 2 is obtained with a brightness difference of 2.8 footlamberts. However, a brightness difference of 5.9 footlamberts is required for the same visibility level if the contrast is only 20 per cent (gray on white). Similarly, greater brightness differences are required for higher visibility levels. To obtain a visibility level of 5 with these same two test objects, brightness differences of 20 and 45 footlamberts, respectively, are required.

As the size of the object increases, it is obvious that smaller brightness differences are necessary for a given visibility level. Thus, to obtain a visibility level of 2 with a 95 per cent contrast, test objects of 2, 3, and 5 minute sizes require brightness differences of 7.6, 2.8 and 1.2 footlamberts, respectively. Similarly, for a visibility level of 5 and a contrast of 40 per cent, the corresponding brightness differences must be 118, 31, and 10 footlamberts.

To aid in visualizing the variation in brightness difference with contrast and visibility level, Figure 4 has been developed from the data of Table II-C. The upper curve of each shaded area represents the brightness of the background and the lower curve represents the brightness of the object. If the object were the brighter, the designations would be reversed. The vertical distance between each pair of curves indicates the brightness difference required for any given visibility level. It can be seen that required relative increases in brightness difference are greater for increases in visibility than for decreases in contrast.

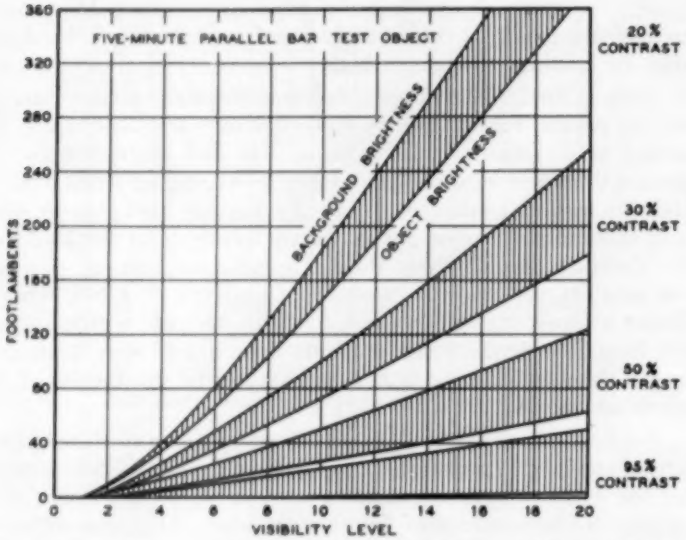

Fig. 4. Graphical representation of the relationships between brightness difference and visibility level for several values of contrast. The brightness difference required for any visibility level is represented by the vertical distance between the upper and lower curves of each shaded area.

It is often overlooked that any specific contrast can be obtained with an infinite variety of combinations of background and object reflectances. The data presented in Figure 5 illustrate how a given visibility level can be maintained with tasks having four different contrasts. Each contrast is obtained with several combinations of background and object reflectances. It is shown that for a particular contrast, however obtained, the illumination must be such that the brightness difference will be constant. All of the data pertain to a visibility level of 5 as determined with the Luckiesh-Moss Visibility Meter. Data were obtained with 5-minute parallel bar test objects with contrasts ranging from 20 to 95 per cent. For each contrast the background reflectances varied from white (80 per cent) to dark gray (20 per cent). Appropriate values of object reflectances were selected for the various contrasts.

To maintain any given visibility level for a constant contrast, the brightness difference between the object and its background must also be constant. For example, from Figure 5 which pertains to a visibility level of 5, the brightness difference is 7.6 footlamberts when the contrast is 95 per cent. In other words, regardless of how the contrast is obtained, with either high or low reflectances, the footcandle

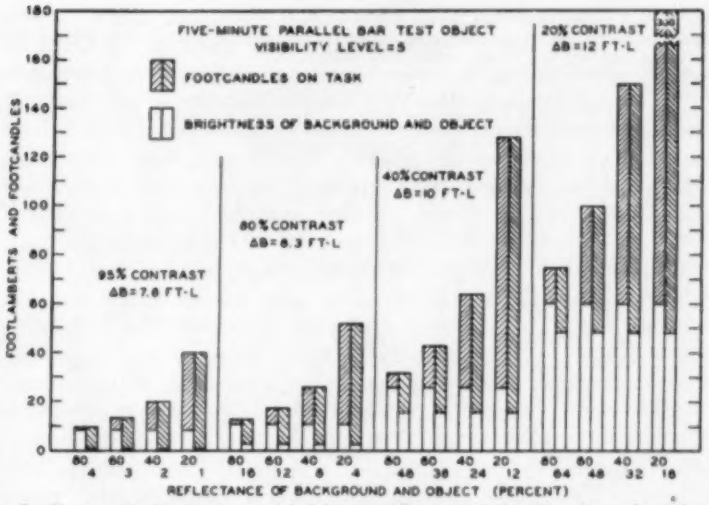

Fig. 5. Footcandle, brightness, and brightness difference relationships for a five-minute test object at a visibility level of 5 with different combinations of reflectances for each of four contrasts. To maintain a constant visibility level, the brightness difference must be constant for each contrast, regardless of how the latter is obtained.

level must be such as to produce a brightness difference of 7.6 footlamberts in order for the task to have a visibility level of 5. This, of course, means that low reflectances of object and background require high footcandle levels. The 95 per cent contrast may be obtained with background and object reflectances of 20 and 1 per cent, respectively. In this case 40 footcandles are required as compared with 10 footcandles when the reflectances are 80 and 4 per cent. Thus, Figure 5 emphasizes the importance of including the reflectances of both the object and its background when determining the footcandle level for any desired visibility level. In other words, how a specific value of contrast is obtained is just as important as the value of contrast itself.

Table II and Figures 4 and 5 illustrate that relatively small brightness differences, and hence, easily attainable brightnesses, are required for high contrast tasks, even to obtain high visibility levels. On the other hand, much higher brightnesses are required to obtain the necessary brightness difference when the contrast is low. However, even with low contrast tasks, the brightnesses required for moderate visibility levels are not excessive, even though the footcandle levels may be difficult to obtain, especially with low reflectances. Nevertheless, such a difficulty should not be considered a serious obstacle to providing adequate means for seeing.

TABLE II

Brightness differences in footlamberts necessary for various visibility levels for three sizes of parallel bar test objects of various contrasts.

Percent Contrast	Visibility Level 1	1.5	2	2.5	3	4	5	7	10
			A. 2-minute test object						
95	0.58	3.0	7.6	14	20	35	52	91	160
80	0.77	3.8	9.6	17	26	46	70	122	218
60	0.86	4.8	12.	22	33	60	89	158	283
40	1.0	6.4	16.	28	42	77	118	211	+
20	1.6	11.	26.	46	69	123	+	+	+
			B. 3-minute test object						
95	—	1.2	2.8	4.9	7.6	14	20	33	52
80	—	1.5	3.4	5.8	9.0	15	23	37	62
60	—	1.7	3.9	6.7	10	18	26	44	77
40	0.37	1.9	4.5	8.0	12	21	31	54	96
20	0.42	2.4	5.9	10.	16	29	45	80	138
			C. 5-minute test object						
95	—	—	1.2	2.0	3.0	5.2	7.6	13	21
80	—	0.65	1.4	2.3	3.4	5.9	8.3	14	24
60	—	0.70	1.5	2.5	3.7	6.5	9.1	15	25
40	—	0.71	1.6	2.7	4.2	7.1	10.	17	28
20	0.16	0.78	1.9	3.2	4.8	8.2	12.	21	37

— indicates a brightness difference produced by less than 1 footcandle.
+ indicates a brightness difference produced by more than 1000 footcandles.

Brightness difference is a basic criterion of visual ability. While contrast is a convenient means of describing one characteristic of a visual task, by itself it is inadequate for evaluating the effectiveness of illumination. The preceding discussion has briefly illustrated how data obtained with the Luckiesh-Moss Visibility Meter can be related to the threshold brightness difference. A remaining problem is to obtain pertinent data for typical work-world tasks which can be used for determining footcandles for equal visibility.

From the data presented in this paper it appears to be necessary to know the contrast and visual size of details of a given object in order to determine the brightness difference required for a specific visibility level. That is, one must be able to decide which of a large number of curves or tables should be used. Fortunately, this is not necessary. In discussing Table I and Figures 2 and 3 it has been pointed out that there are certain constant relationships between threshold and suprathreshold values of illumination and brightness difference. In a previous paper[4] it has been shown that the relationship between visibility level and relative footcandle level above the threshold for a wide range of sizes, contrasts, and configurations of test objects can be obtained by means of a single curve. Brightness difference is a function of illumination and reflectance difference, the latter being constant for any given

object. Thus, only easily measurable quantities—visibility level with an existing footcandle level—are necessary to determine the illumination required for any other suprathreshold visibility level. This new illumination will provide the necessary brightness difference.

A brief study of other available data indicates that the brightness difference concept may have interesting application to the appraisal of comfort and ability to see when applied to the task and surroundings. It is possible that brightness difference may be a more useful criterion than brightness ratio.

It should be emphasized that the brightness difference concept is not new, but it has not been given the importance it deserves. Of the relatively few investigators who have mentioned it, the work of three appears to be particularly pertinent. Beuttell,[5] in developing a method for computing values of illumination for various classes of work used contrast in terms of reflectance difference. He applied footcandle factors so as to obtain a constant brightness difference equal to that of a basic task. Hopkinson, Stevens and Waldram[6] pointed out that contrast means "the sensation of difference between juxtaposed things" and discussed in considerable detail various methods of dealing with contrast, including brightness difference. Weston[7] investigated the relation between illumination and visual efficiency and presented his results as plots between visual performance and brightness difference. It is possible that brightness difference may make it possible to develop better relationships among the various methods and criteria used to evaluate seeing.

This brief summary illustrates that the brightness difference concept affords an interesting approach to a better understanding of the benefits that can be received from higher levels of illumination. This concept places greater emphasis upon brightness in terms of absolute, rather than relative values. The relationships between threshold and suprathreshold data indicate that a convenient means is available for determining the footcandles necessary for any desired visibility level.

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THE DESIGN AND OPHTHALMIC PROPERTIES OF BINOCULAR MAGNIFICATION DEVICES*

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Consider the case of an emmetropic observer or an observer who has been made emmetropic by the provision of spectacle lenses worn in the usual fashion close to the eyes and the magnification properties of which may be neglected.

It is desired to provide for such an observer a magnification device which will allow him to see a near object clearly and singly with both eyes. If the discussion is restricted to thin-lens systems, the following variables are at the disposal of the designer:

F, the power of the lens
h, the eye-lens separation**
$\triangle$, the prismatic power of each lens.

It is conceivable to refine and extend the discussion developed here by introducing thick lenses or complex lens systems. These may be fitted into the framework of this paper, however, by the calculation of their principal point power and the specification of the eye-lens separation from their second principal point. For an example of this approach, see references 4 and 5.

Other variables entering the discussion are

x, the working distance or eye-object separation,
u, the distance between the object and the lens ($u = h - x$),
$2a$, the subject's interocular distance,
A, the accommodation exerted by the observer,
K, the convergence induced in the subject in association with each diopter of accommodation, K, being assumed to be a constant in the range of accommodation under consideration, and

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**h, in the following discussion, is used in two ways: when the lens power is considered it measures the distance between the entrance pupil of the eye and the lens, and in the consideration of the prism power it measures the distance between the center of rotation of the eye and the lens. When h is reasonably large, i.e., a few centimeters, the difference between the two becomes negligible. This has been assumed to be the case in this paper.

P, the subject's distance phoria.

The size magnification, which is M, the ratio of the retinal image sizes of a given object with and without the device, consists of several factors (Ogle[3]). As mentioned before, we shall restrict ourselves to a discussion of thin lenses and this reduces one of the factors, the "shape" factor, to unity. Another factor is the "distance" factor which expresses the increase of the retinal image of an object, maintained in clear focus, that is approached to the eye. This is, of course, an excellent way of achieving magnification but in so far as a subject with good accommodation is able to bring an object close to the eyes, still maintaining good focus, it is not a special property of a magnification device which enables him to relax accommodation and to achieve the same result. The third factor in the magnification expression, the "power" factor, depends on the lens power and the eye-lens separation and taken by itself expresses the increase in size of the retinal image of an object at a given constant distance from the eyes with the magnification device in place as compared to the unaided eyes.

While the following formulas have been derived solely by the use of first-order object/image relationships, the limitations of this approach must be kept in mind when making practical application of them. An interesting application of aspherical curvatures has recently been made in this connection.[1]

A lens of power F placed at a distance h from the center of the entrance pupil of the eye will increase the retinal image of an object at a distance x from the center of the entrance pupil by a factor M over the retinal image size of the object in the unaided eye, where M is given by[2, 4, 5]

$$M = \frac{h - u}{h - u + hFu} = \frac{x}{x(1 - hF) + h^2F} \bullet \quad (1)$$

If u' is the distance between the lens and the image of the object as formed by the lens, the accommodation exerted by the subject is

$$A = \frac{1}{h - u'} = \frac{Fu + 1}{h - u + hFu} \bullet \quad (2)$$

This must obviously be equal to or greater than zero. In a practical situation we may want a subject to exert A diopters of accommodation.* This means that with an eye-object separation $h - u$ (u is

*A, in this paper, refers to ocular accommodation, i.e., in the emmetrope the Reciprocal of the distance between the eye and the far point of the eye in the accommodated state. When A does not exceed about 4 or 5 D. th difference between ocular and spectacle accommodation may be ignored for practical purposes.

negative when a real object lens is considered), and an eye-lens separation h, we must use a lens of power

$$F = \frac{1 + Au - Ah}{huA - u} \quad \bullet \tag{3}$$

Example. Suppose we want to fit a magnification device at a distance of 10 cm. in front of a subject's eyes and he is to view an object 40 cm. in front of his eyes, while using 1 D. of accommodation. What lens power is required and what is the retinal image size of the object as viewed through this lens compared to viewing it with the unaided eye (supposing the subject to be able to accommodate for this distance or supposing him to be fitted with a near addition fitted very close to his eyes)? We have $u = -.30$ m, $h = .10$, $A = 1$, and, substituting in equation (3), we obtain

$$F = 2.22 \text{ D.}$$

Substituting in equation (1), we have

$$M = 1.20,$$

showing that a 20 per cent magnification has been achieved compared to the retinal image size if the object had remained at 40 cm. and were observed either by the unaided eye (exerting the accommodation necessary to form a clear retinal image) or by the eye in an unaccommodated or partially accommodated state but assisted by lenses worn very close to the eye and hence of negligible magnifying power. In this connection it is of interest to note what range of clear vision is available to the observer.

Relaxing his accommodation fully, he can still see a point clearly at a distance of x_{max} where

$$x_{max} = \frac{1}{F} + h \quad \bullet \tag{4}$$

It is .55 meters in this case.

The closest point clearly visible with the lens in place, x_{min}, depends on his maximum accommodation A_{max} and is given by

$$x_{min} = \frac{1 - hA_{max}}{A_{max} + F(1 - hA_{max})} + h \quad \bullet \tag{5}$$

If the hypothetical observer had a 3 D. maximum accommodation, it would be 25 cm.

In summary, the lens, placed at 10 cm. from the observer, which permits him to see an object at 40 cm. clearly with 1 D. accommodation, has power 2.22 D. and magnifies the retinal image 20 per cent

over to its size without a lens. With the lens the subject can see objects clearly from 55 cm. inwards, the minimum distance depending on his maximum accommodation.

THE PRISMATIC COMPONENT

If a magnification device is to be used binocularly it is necessary to ensure that the subject is capable of exerting the convergence necessary to align the two foveas with the images of the object as formed by the two lenses.

Figure 1 shows diagrammatically how an object O is imaged by two lenses (one before each eye) of power F each decentered inward

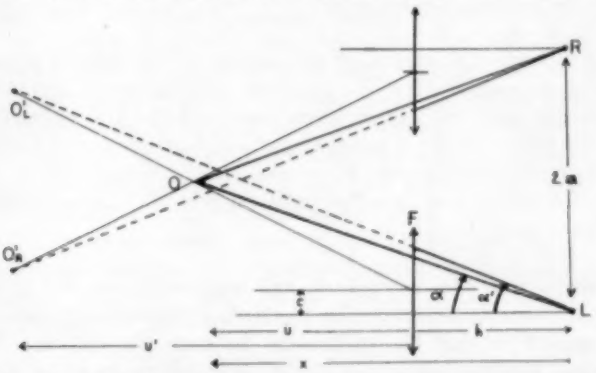

Fig. 1. An object O is imaged by lenses of power F decentered nasally through a distance c and placed at a distance h in front of the observer's two eyes R and L. The object is at a distance u in front of the lenses and x in front of the eyes and its image for the right eye is at O_R' and for the left eye at O_L', both at a distance u' in front of the lens. To converge on the object O, a total convergence of 2α is required without the lenses, but with the lenses in place a convergence of $2\alpha'$ is required to bring the primary lines of sight of the eyes in alignment with image O_R' and O_L' produced by the lenses.

through a distance c with respect to the primary direction of each eye. The images of this object formed by the right and left lenses are at O'_R and O'_L respectively. It is to be noted that the images are situated so that the accommodation necessary to see them clearly is $1/(h - u')$ while the convergence necessary to see them singly is equal to $2\alpha'$. Obviously it is essential to ensure that the accommodation and convergence are harmoniously related so far as the individual subject is concerned. Since the lens power F has been previously designed for the accommodation, the object distance, and the eye-lens separation, the remaining variable, the prismatic power of the lenses, can now be used to control the convergence.

It must be remembered that the lens used in the magnification device is to be placed at some distance in front of the eye so that an effectivity correction must be made for the prism power. The following approach, which is based on the use of clinically obtained data, includes in its development all the necessary steps such as effectivity correction. It makes the assumption that the patient's induced near phoria must be rigidly corrected. In the light of such clinical considerations as the fusional reserves, individual variations of the general approach adopted here are feasible and remain at the discretion of the designer.

When the subject accommodates A diopters there will be induced a degree of convergence equal to

$$K\ A,$$

where K is a constant expressing the amount of convergence induced per diopter of accommodation. To conform with the meter-diopter system of units used here, the unit of prism power will be 100 prism diopters. Hence if a subject shows 6 prism diopters of accommodative convergence per diopter accommodation, $K = .06$. If the subject has a distance phoria of P the state of convergence of his eyes with an accommodation A in play is given by

$$P + K\ A.$$

P is positive if we have esophoria and negative in the case exophoria.

It is desirable to design the prismatic component of the lenses in the magnifier so that the inclination between the subject's lines of sight when viewing the images of the object as produced by the lenses will be precisely the same as the inclination they have assumed under the influence of the distance phoria and accommodational convergence. In other words, in order to fuse the images of the object produced by the lenses of the magnified he should have to exert just as much convergence as he has naturally assumed due to accommodation and distance phoria. (This may, of course, be an ideal that cannot always be reached.)

When a lens of power F is decentered laterally through a distance c the angle between the primary direction and the line of fixation directed to the image of an object in the observer's median plane at a distance u from the lens (see Figure 1) is given by

$$a' = \frac{-a - cFu}{u - hFu - h} = \frac{a + \Delta u}{(h - u')\ (Fu + 1)}, \qquad (6)$$

where $1/u' = 1/u + F$, h is the eye—lens separation* and a is half

*For the sake of accuracy it must be noted that here h is measured from the center of rotation of the eye. The inaccuracy involved is not serious while the simplification thus introduced is considerable.

the interocular distance. Remembering that $1/(h - u') = A$ and that the total convergence required is $P + K A$, we can set up the following equations

$$2a' = P + K A$$

$$\frac{(a + \Delta u) \cdot 2A}{Fu + 1} = P + K A$$

which yield

$$\triangle = \frac{(P/A + K)(Fu + 1) - 2a}{2u} \bullet \qquad (7)$$

$\triangle$ is positive if the prism is base-in, negative if the prism is base-out. $\triangle$, K and P are expressed in units equal to 100 prism diopters if A and F are in diopters and a and u in meters. The substitution of $\triangle$ for cF can be made as desired; it merely states that prism power $\triangle$ in units of hundred prism diopters is introduced by decentering a lens of power F diopters through a distance c meter laterally as measured from the straight forward direction of the line of fixation, nasal being regarded as positive, temporal negative.

Applying the foregoing theory to our subject, and assuming that he has a distance exophoria of 2 prisms diopters, an interocular distance of .06 meters and $K = .06$, we have, since $A = 1$ D, $F = 2.22$ D, $u = -.30$ meters,

$$\triangle = .078 = 7.8 \text{ prism diopters.}$$

SUMMARY OF ILLUSTRATIVE CASE

It is desired to fit an emmetropic observer with a binocular magnification device for a working distance of 40 cm., the object being placed in his median plane. The observer has a distance phoria of 2 prism diopters exophoria, an interocular distance of 6 cm., an accommodative convergence of 6 prism diopters per diopter of accommodation. It is found advisable to have the observer accommodate 1 D. and the maximum eye-lens separation that can be obtained in practice is 10 cm.

Substituting in equations (3) and (7) the lens and prism powers of each lens are determined to be 2.22 D and 7.8 prism diopters each.

Substituting in equation (1) the size is found to be 1.20.

SUMMARY

In designing binocular magnification devices essentially three variables are available, the lens power, the prism power, and the eye-lens separation. Formulas are given enabling the calculation of these in terms of the object distance and such clinical findings as the subjects

available accommodation, distance phoria and accommodation-convergence relationship. Other formulas are set out to express the magnification properties of such lenses and the range of clear vision through them.

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ANNOUNCEMENT

SELECTIVE SERVICE COLLEGE QUALIFICATION TESTS

Major General Lewis B. Hershey, Director of Selective Service, has announced the fifth series of Selective Service College Qualification Tests will be given on Thursday, December 9, 1954, and Thursday, April 21, 1955, at more than 900 testing centers.

Some 550,000 students have already been tested under this program, which began in 1951. Upward to three quarters of a million students will have been tested by next spring.

Students currently deferred on the basis of test scores or prescribed class standing number approximately 162,000.

Students whose academic year will end in January, 1955, have been urged to take the December test so they will have a test score on file at their local boards before the end of their academic year, at which time their boards will reopen and consider their cases to determine whether they should again be deferred as students.

Applicants for the tests will mail applications for the December 9, 1954, and April 21, 1955, administrations to Science Research Associates, Chicago, in Self-addressed envelopes which may be obtained at local boards. Bulletins of information concerning the test are also available at the local boards.

Applications for the December 9 test must be postmarked no later than midnight Tuesday, November 23, 1954. Applications postmarked after midnight of that date cannot be accepted for that test.

To be eligible to apply for the Selective Service tests a student must: (1) intend to request deferment as a student; (2) be satisfactorily pursuing a full-time course of instruction; and (3) must not previously have taken the qualification test.

The present criteria for deferment as an undergraduate student are either a satisfactory score (70) on the qualification test or specified rank among the male members of the class (upper half of freshman class, upper two-thirds of sophomore class, or upper three-fourths of junior class).

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ACADEMY ENCOURAGES FREEDOM OF THOUGHT

The lack of agreement in thought between two men high in Academy circles has been noted recently in an optometric magazine editorial.* The author of this editorial has actually mentioned one of the strongest virtues of the Academy, namely, its tolerance of divergent viewpoints among men of recognized ability.

The Academy is a powerful force for good in optometry for the very reason that there is no dogma, strict set of tenets, or party line handed down from above. Each fellow is respected as an individual who, in gaining his Fellowship, has demonstrated his excellent qualifications. Each Fellow is both entitled and expected to have his own

*Editor's Note: Dr. Hirsch is referring to an unsigned editorial which appeared in the Optical Journal and Review of Optometry. Lord Charnwood of London had suggested that dispensing opticians fill ophthalmic prescriptions written by optometrists. President Morgan pointed out that optometrists should dispense the materials they prescribed for their own patients. Both men are members of the Academy.

opinions; nor is any Fellow or officer of the Academy expected to withhold his opinions merely because of Academy affiliation.

This freedom of thought among Academicians is not merely restricted to scientific affairs, but includes concepts of philosophy, professionalism, as well as completely non-optometric aspects of human thought such as politics and religion. The Academy recognizes the value of divergence of thought in all aspects of intellectual activity, and Academy Fellowship does not necessitate giving up individual freedom of thought or expression.

To be sure, there are points on which all Fellows are expected to agree, and these are clearly set forth and subscribed to by the applicant when he accepts Fellowship. All Academy members are agreed that optometry cannot be practiced properly in commercial surroundings, that the professional optometrist does not engage in advertising campaigns, and that other similar commercial practices deny us professional standing. However, it is implicit in the Academy Constitution that on all points beyond these areas of agreement there is complete freedom of thought and expression reserved for the Fellows.

To be sure, also, there is a place in optometry for party discipline. In the American Optometric Association, which is a democratically governed political body for the entire profession, hewing to the line is a practical necessity. The Academy, through resolutions of the Executive Council and through Editorials in this *Journal*, has repeatedly urged Fellows to support the A.O.A., follow its policies, and help in the democratic formulation of these policies. Even here, however, the individual member of the A.O.A. in agreeing to follow the polices of the organization does not give up his right to dissent or to speak in defense of his ideas.

Optometry is seemingly at a point in its development where unanimity of thought is far from an actuality. Such unanimity of thought can never be forced and, in fact, is never realized. Were there no disagreement among men with respect both to the scientific and the professional aspects of optometry, it would mean either that independent thinking had been suspended or that the field was so sterile that all could agree. There is unanimity in the Academy on this point at least, and that is that both of these possibilities are not actualities.

Finally, and in the same vein, all Fellows are urged to attend the Annual Meeting in Toronto next month to see how optometric science is advanced through divergent opinions. In our young profession which unfortunately often is characterized by the blind adherence to specific dogma, it is enlightening indeed to see and hear Academicians exhibiting scientific scepticism, but also respecting each other's opinions and

intellectual integrity. As a result of these Annual Meetings, optometric science benefits far more from dissent and disagreement than through blind acceptance of questionable material. We challenge any optometrist to attend an Annual Meeting and not come away feeling prouder of his profession. It just can't be done.

MONROE J. HIRSCH

TRANSACTIONS OF THE AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization data, news, professional problems and ideals, as these relate to the Academy.

SCIENTIFIC PROGRAM—TORONTO ACADEMY MEETING

The annual meeting of the American Academy of Optometry will be held December 11-14, 1954 at the Royal York Hotel, Toronto, Ontario, Canada. The Papers and Program Committee, Dr. John D. Perry, Jr., Winston-Salem, North Carolina, chairman, present the following speakers and original papers for the general Scientific Program of this four day meeting.

Saturday, December 11, 1954

8:30 Registration.

10:00 Business Meeting. President's Annual Report. Meredith W. Morgan, Jr., Ph.D. Secretary's Annual Report. Carel C. Koch, O.D. Announcements by Chairman of the Papers and Program Committee. John D. Perry, Jr., O.D. Announcements by Chairmen of the Sections. Dr. L. W. Madigan, O.D., *Aniseikonia*. Dr. I. Finkelstein, Ph.D., *Contact Lenses*. Dr. M. J. Hirsch, Ph.D., *Pathology*. Dr. Richard Feinberg, Ph.D., *Occupational Optometry*. Dr. P. L. Connolly, O.D., *Orthoptics*.

11:00 The Effect of Fixation Distance and the ACA Ratio on the Angle of Anomaly, Part I. Max Schapero, O.D., Assistant Professor of Optometry, Los Angeles College of Optometry. Frank W. Weymouth, Ph.D. Los Angeles College of Optometry. Margaret Hester, O.D. Los Angeles College of Optometry.

11:30 Discussion*

11:40 The Components of Accommodation. Gordon G. Heath, O.D., M.S., School of Optometry, University of California.

12:20 Luncheon Recess.

1:45 The Stimulus to Accommodation and Some Practical Implications. Merrill J. Allen, B.Sc., Ph.D., Associate Professor, Division of Optometry, Indiana University.

2:25 Physiological Factors in Multifocal Corrections. Robert E. Bannon, O.D., Bureau of Visual Science, American Optical Co.

3:05 The Method of Concordance in Affections of The Horizontal Recti. Joseph I. Pascal, M.A., O.D., M.D., Director of Eye Department Stuyvescent Polyclinic, Lecturer, N. Y. Polyclinic Medical School.

3:30 Analysis of One Thousand Consecutive Clinic Records. William G. Walton, Jr., O.D., Assistant Professor of Optometry, Penna. State College of Optometry.

*A ten minute Discussion period follows each paper.

4:00 The Relationship Between Accommodation and Accomodative Convergence. Gerald Westheimer, Ph.D. School of Optometry, Ohio State University.
4:30 Perceived Curvature of Surfaces Normal to The Primary Sagittal Line. Glenn A. Fry, Ph.D., Director, School of Optometry, Ohio State University.
5:10 Dinner Recess.
7:30 A New Method For Measuring The Angle of Squint and The Angle of Anomaly. Merton C. Flom, B.S., M. Opt., Clinical Instructor in Optometry, School of Optometry, University of California.
8:10 The Sanctions of Professional Ethics. Eugene Freeman, Ph.D., Dean. Chicago College of Optometry.
8:50 Report, European Collaborations on Contact Lenses. John C. Neill, O.D., Penna. State College of Optometry.

Sunday, December 12, 1954

9:00 Section Meetings.
Aniseikonia—Private Dining Room No. 9
Contact Lenses—Private Dining Room No. 8
Occupational Optometry—Private Dining Room No. 10
Orthoptics—Roof Garden
Pathology—Private Dining Room No. 7
11:10 A Sign of Manifest Heterozygosity In Carriers of Color Deficiency. Ingeborg Schmidt, M.D., Division of Optometry, Indiana University.
11:35 An Evaluation of Scleral Tonometry—Its Reliability, Validity, and Clinical Applicability. Monroe J. Hirsch, Ph.D., Ojai, California.
12:20 Chapter Luncheon. (Tudor Room)
2:30 Evolution and The Human Eyes. John Zettel, Jr., O.D., Cincinatti, Ohio.
3:10 Three Case Reports of Reduced Acuity. H. Ward Ewalt Jr., B.S., O.D., Pittsburgh, Pa.
3:40 Myopes vs. Non-Myopes, a Comparison. Francis A. Young, Ph.D., Department of Psychology, State College of Washington.
4:20 The Practical Demonstration and Application of the Objective Determination of The Visual Acuity on The Basis of The Optikinetic Nystagmus. William P. Schumann, O.D., Vineland, N. J.
5:00 Decartes' Contact Lens. Jay M. Enoch, B.S. in Opt., School of Optometry, Ohio State University.
5:25 Dinner Recess.
7:30 Turville Infinity Binocular Balance Test. Meredith W. Morgan, Jr., Ph.D., Professor of Physiological Optics and Optometry, School of Optometry, University of California.
8:10 A Case Study by Graphic Analysis. Henry W. Hofstetter, Ph.D., Director, Division of Optometry, University of Indiana.

Monday, December 13, 1954

9:00 Section Meetings.
11:10 Changes in Fixation Disparity and Heterophoria During and After Wearing of Prism. Darrell B. Carter, M.S., O.D., Assistant Professor of Optometry, University of Houston.
11:50 Optical Limitations in The Correction of Astigmia. Fred W. Sinn, O.D., Professor of Physical and Geometrical Optics, Penna. State College of Optometry.
12:25 Luncheon Recess.
2:00 Applied Optics and Prescription Writing. G. Maurice Belanger, B.A., Ottawa, Canada.
2.40 The Stability of Heterophoria. Meredith W. Morgan, Jr., Ph.D., Professor of Physiological Optics and Optometry, School of Optometry, University of California.
3:20 Lighting Levels For The Forgotten Man. Sylvester K. Guth, B.S., E.E., D.O.S., and A. A. Eastman, B.S., E.E., General Electric Co., Nela Park, Cleveland, Ohio.
4:00 Business Meeting. Dr. Meredith W. Morgan, Jr., Ph.D., presiding.
6:00 Cocktail Hour. (Banquet Hall)

7:00 Annual Roundtable Dinner (Formal) Banquet Hall. Presiding Officer: Meredith W. Morgan, Jr., Ph.D. Speaker: John W. Fisher, LL.D. Toronto, Ontario.

Tuesday, December 14, 1954

9:00 Section Meetings.
11:10 Progress Report of Partially Blind Cases. Irving Vica, O.D., Albany, N. Y.
11:40 Occupational and Avocational Trends. R. A. Sherman, D.O.S., Director, Occupational Vision, Bausch and Lomb Optical Co.
12:15 Lunch Recess.
1:45 Lighting For The Optometrists' Office. Howard Haynes, B.S. in E.E., General Electric Co., Nela Park, Cleveland, Ohio.
2:15 The Variation of Visual Characteristics in School Children as Measured by the Orthorater. Fred W. Jobe, Director of Opthalmic Research, Bausch and Lomb Optical Company.
2:55 Some Observations of The Pulfrich Stereophenomenon. Ira Schwartz, B.A., O.D. Research Optometrist, U. S. Naval Medical Research Laboratory, and Milton S. Katz, M.A. Research Psychologist, Civilian Scientist, U. S. Naval Medical Research Laboratory.
3:35 Progress Reports on Current Research Projects in Optometric Colleges.
4:15 The Relationship of Birthplace of Parents and Grandparents to The Refractive Error of the Child. Melvin C. Nadell, O.D., Ph.D., Los Angeles College of Optometry ,and Monroe J. Hirsch, O.D., Ph.D., Ojai, California.
5:00 Adjournment.

The programs for the additional clinical speakers and papers to be presented at the five special Section meetings of the Academy during the annual meeting at Toronto will be distributed at the time of registration. All Academy members are expected to attend and hotel reservations may still be made direct to the Royal York Hotel, Toronto.

INSTRUMENT REVIEW

VISUAL FIELD EXAMINATION BY TACHYSTOSCOPIC MULTIPLE PATTERN METHOD

The multiple pattern method of visual field examination utilizes the principle of tachystoscopic or flash presentation of simple, abstract patterns of lines, dots and crosses to the fixing eye. These lines and dots act as visual stimuli in the various parts of the visual field.

The patterns are printed on 12x18 inch white cards in white fluorescent sulfide ink so that under ordinary room light only a black central fixation dot is visible. When the card is illuminated by a flash of ultraviolet radiation of ¼ second duration the pattern stands out clearly against the background of the card and acts as a stimulus to extra foveal vision in that area. The duration of the flash which activates the pattern is sufficient to allow the patient to see the pattern, if that area of the visual field is not blind, but is too short to allow a shift of fixation. If a portion of the visual field is defective the stimulus of

the pattern in that area will not be detected and the patient will describe the pattern erroneously. Each pattern is designed to test specific areas of the visual field so that errors in describing the pattern will deliniate the type of field loss.

A composite of the pattern stimuli covers most of the visual field within the 30° radius and encompasses the majority of visual field defects. Errors in describing the patterns may be quickly checked off on a chart of the pattern composite as a means of recording the examination. Areas of visual field loss are then seen at a glance on this chart.

The test card patterns are bound in a book of ten cards which may be fastened into the instrument containing the ultraviolet tube. The cards are exposed by turning the pages one at a time. The instrument is equipped with a chin rest and occluder and two button switches one of which turns the light on or off and the other controlling the automatic flashing device.

In the average patient each eye can be tested with all 10 patterns in less than 2 minutes. The instrument will plug into any 110 volt AC outlet and is the size of a small suit case with handle. All patterns present two or more stimuli in the visual field and thus take advantage of the principle of double stimulation and the "extinction phenomenon" to increase the sensitivity of the test.

This method reviewed does not aim to replace standard perimetric techniques but only to supplement them. It makes available to patients the benefits of a visual field examination which might otherwise be neglected.

D. O. HARRINGTON AND M. FLOCKS*

*From the material presented at the XVII International Congress of Ophthalmology and the American Academy of Ophthalmology and Otolarnygology, New York City, September, 1954. Jenkel-Davidson booklet. The Field Screener is manufactured by the Jenkel-Davidson Company, 366 Post St., San Francisco, California.

CURRENT COMMENTS

Terry Judith Parkins
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department: such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

ACCIDENT PRONE HUNTERS

The Safety Committee of the Minnesota Conservation Federation has just completed a study of hunters who were involved in shooting

accidents while hunting.* The study included the vision of the hunter, his knowledge of hunting procedures, of guns and his personality and emotions. Ninety-three persons who had shot others were tested. The visual tests included visual acuity, color vision, horizontal phoria tests and tests for depth perception. The tests were run on the Ortho-Rater and the scores made by these hunters were analyzed by Drs. W. J. Bushard and T. R. Fritsche of the Minnesota Academy of Ophthalmology and by Dr. R. O. Lindquist of the Minnesota Optometric Association who worked as a team on this project. Dr. Starke R. Hathaway, Director of the Division of Clinical Psychology at the University of Minnesota Medical School reviewed the personality tests.

These same tests were made on an entirely similar control group. This control group achieved scores much better than those secured by the shooters. Only 33 per cent of the shooters were found to have normal distance vision, and the hunting accident group came out second best in all of the other visual tests.

In summing up the findings of the study it is evident that a hunter who shoots another hunter accidentally is apt to be impulsive, he is apt to have poor judgment and have poor vision.

FEDERAL RESEARCH IN 1955

According to the National Science Foundation, Federal agencies will earmark $1.99 Billion for research in 1955. Of this amount about 87 per cent will go to the physical sciences including those projects sponsored through the Secretary of Defense. The remainder will be allotted to agriculture, health, welfare, transportation, communication, and the development of natural resources.

GLAUCOMA WORKSHOP

The Indiana Chapter of the American Academy of Optometry held a Glaucoma Workshop, October 10, at the Indiana University Medical Center in Indianapolis. The sessions stressed the accepted optometric method for the early detection of increased intraocular tension and its effects. Dr. John M. Thompson, ophthalmologist of South Bend and Dr. Neal J. Bailey, Assistant Professor of Optometry at the Division of Optometry, Indiana University, Bloomington, were the speakers. Dr. D. O. Elliott, Jr., of South Bend presided.

NEWS BRIEFS

The golden anniversary alumni reunion of the Los Angeles College of Optometry was held November 13, 14, and 15. One of

*Alfred M. Lansing, Moose or Man? Colliers. October 29, 1954, pp. 31-33.

the features of the meeting was a trip through the M-G-M studios in Culver City where a complete review of CinemaScope was presented. . . . Mr. Norman A. MacLeod, Providence, was elected President of the American Board of Opticianry at its meeting in New York City, September 20. . . . The Alumni Association of Southern College of Optometry will meet in Memphis, December 5 and 6. Dr. Irving P. Filderman, Memphis, president of the group will preside. The Sunday speakers will be Dr. Charles Schleifer, "Modern Clinical Practices," Dr. O. M. Cole, "Occupational Vision" and Dr. E. M. Broom, "Optometric Research Procedures." The Monday speakers are Dr. William D. Paisley, "Practice Development"; Dr. William Sullins, "Visual Training" and Dr. Filderman, "Subnormal Vision." . . . The annual Reading Institute of Temple University, Philadelphia, will be held the week of January 24, 1955. Optometrists are invited to attend. For further information address the Reading Clinic, Department of Psychology, Temple University, Philadelphia. . . . At the September 24 quarterly meeting of the B. V. I. the announcement was made that the plan for raising approximately one million dollars a year over the next five years is now being studied with the hope that the projected broad scale public relations program dealing with better vision can begin early in 1955. . . . Dr. George W. Keevil, Toronto, advises that Academy members and guests coming to the annual meeting of the Academy in Toronto, December 11-14, and bringing instruments or books with them may clear these items with the Customs Department or with the Toronto Convention Tourist Association, 30 Bloor Street West, Toronto, where assistance will be given. . . . The American Optometric Association announces that revised prints of the twenty-one minute film "More Than Meets the Eye" are now available for distribution. This color film and its accompanying sound track may be secured from the office of the association, 4030 Chouteau Avenue, St. Louis. The cost is $200.00. . . . Dr. S. K. Guth, General Electric Company, Nela Park, Cleveland, has just returned from a trip to Iceland where he presented several papers dealing with lighting and vision before the Illuminating Engineering Society of Iceland. . . . Miss I. M. Whitney and Mr. A. E. Turville, Northampton, England, each presented papers before the German Optometric Congress in Berlin in September. Miss Whitney is treasurer of the British Chapter of the Academy and Mr. Turville is president of the Chapter. . . . The geographical directory which follows this department in this issue of the JOURNAL lists the names and addresses of 678 members of the Academy. This is the high point in academy membership.

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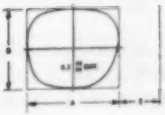

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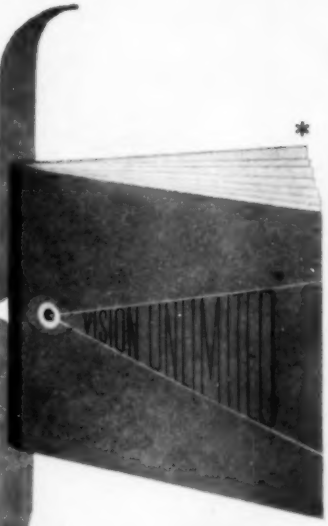

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